of electricity divided by the mass of the hydrogen atom it should be about 9660.

The model has thus been tested numerically on three independent points. It gives 2·32 for the ratio of the wave-lengths instead of 2·00, and it gives 7110 or 1550 for the value of e/m instead of 9660, according as we use the first or second band. If we consider the simplicity of the assumptions made, and the room there is for modification (*e.g.* making k different for the different linkings), the agreement must be regarded as gratifying.

The other maxima in the absorption spectrum are possibly due to more complex molecules.

This is incidentally the first time that chemical bonds have been connected mathematically with absorption bands.

Spectroscopic Investigations in Connection with the Active Modification of Nitrogen. II.—*Spectra of Elements and Compounds excited by the Nitrogen.*

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[PLATE 6.]

Introductory.

In continuation of previous accounts of the active modification of nitrogen,[*] and of the spectrum of the afterglow which is associated with it,[†] the present paper gives further details of the spectra which are developed when various elements and compounds are introduced into the glowing gas. Preliminary investigations of the spectra were made by direct observation, and with a small quartz spectrograph, and when greater resolving power was required a larger quartz spectrograph and an instrument of the Littrow type were used.

The arrangements for producing the afterglow were as described in the previous papers. By means of a mechanical pump a stream of purified

nitrogen at low pressure was passed through the discharge tube, and the afterglow was observed in a side tube, into which the various substances were introduced as required. It will be remembered that a discharge with condenser and spark gap is necessary to develop the afterglow with maximum intensity.

Later experiments have shown that the afterglow is also generated by the ring discharge produced by electromagnetic induction when the pressure of the nitrogen is appropriately adjusted. The spectrum of the exciting discharge is identical with that of the condensed discharge which has already been described; that is, the first positive bands of nitrogen are feeble, the second positive bands very intense (giving a bluish colour to the ring), the third positive group absent, and the fourth positive bands present.

We mentioned in our previous paper (p. 377) that the deep yellow after-glow was destroyed by a small amount of oxygen in the nitrogen employed, and that only a bluish-white luminosity was then visible. This is due, as we have since ascertained, to the formation of a small quantity of nitric oxide by combination of oxygen and nitrogen in the discharge; for the same effect is produced if a very small quantity of ready made nitric oxide is introduced into the stream *after* it has passed the discharge tube. Larger quantities introduce a different phenomenon—the yellow-green flame with continuous spectrum.* The effect of a small nitric oxide admixture is to suppress the α-group of afterglow bands, leaving the rest of the afterglow spectrum untouched.

Metallic Elements.

Sodium.—It has already been pointed out by one of us that when sodium is heated a little above its melting point in the presence of active nitrogen, the sodium spectrum is developed with great brilliancy; when heated more strongly, the vapour close to the metal becomes visibly green, and in this region the D lines almost vanish, while the pair of green lines about 5685† is shown very strongly. Other lines of the subordinate series are also very bright, and lines of potassium appear as impurities.

As regards the principal series, the photographs suggest that the suppression of the D lines does not so much indicate a tendency towards the extinction of this series as a change in the position of maximum intensity to the next pair of lines in the series near 3303, which is the strongest in the whole spectrum; other lines of the principal series at 2853 and 2680 are also well visible.

In the first subordinate series the greatest intensity is towards the red

* R. J. Strutt, 'Roy. Soc. Proc.,' in course of publication.
† Wrongly referred to in the Bakerian Lecture as the E line.

end, and the colour of the glowing vapour indicates that the maximum occurs at the green pair 5685. The second subordinate series is relatively very weak. Apart from the redistribution of intensity in the principal series, however, the spectrum approximates very closely to that given by sodium in the oxy-hydrogen flame or electric arc.

The suppression of the D lines recalls an experiment described many years ago by Lockyer,[*] in which a similar result was obtained. In this case an electric discharge was passed through a capillary tube which was in connection with a wider tube containing heated metallic sodium, the platinum electrode nearest to the metal being a few inches above it. There was no obstruction between the electrode and the sodium, and the only gas present was the hydrogen given off by the metal.

The similar results obtained in hydrogen and nitrogen suggested that in both cases the effect might be due to the production of the spectrum under reduced pressure. We have not, however, been able to produce the same phenomenon by passing a discharge through sodium vapour in a vacuum tube, although the lines of the subordinate series were well displayed under these conditions.

Potassium.—The photographed spectrum was rather faint, but it showed very clearly the lines of the principal series at 4046, 3447, 3217, and 3102, the first named being by far the strongest. Several lines belonging to the two subordinate series were shown faintly, and there were feeble indications of a band fading to the violet, with its head about 460.

Magnesium.—The spectrum of this metal was only observed with difficulty, and the photograph obtained was not very strong. Nevertheless it sufficed to show that the spectrum did not contain any of the characteristic spark lines, such as that at 4481·3. The characteristic flame line at 4571 appeared faintly, while the adjacent line at 4703, which is a much stronger line in the arc spectrum, did not appear. The spectrum thus approximates closely to that given by the flame, but it tends to be intermediate between the flame and the arc. The lines photographed are shown in the following table :—

Wave-length.	Intensity in glow.	Remarks.
4571 ·33	1	Characteristic flame line.
3838 ·44	10	1st line of triplet, 1st subordinate series.
3336 ·83	1	„ „ 2nd „ „
3097 ·06	3	„ „ 1st „ „
2852 ·22	2	„ „ 1st „ „
2779 ·94	3	Arc line, not included in series.

The *b* group was observed visually, but was not photographed.

* 'Roy. Soc. Proc.,' 1879, vol. 29, p. 266.

Mercury.—The mercury line spectrum is well developed in active nitrogen, and the photograph shows all the stronger lines of the arc spectrum which are given by Kayser and Runge. With the exception of the pair 5790, 5769, and the line 4078, all the lines photographed belong to the two triplet series, and include numbers 4 and 5 of the first subordinate series, and numbers 3 and 4 of the second subordinate series. The relative intensities of the lines are not notably different from those of the arc spectrum. Comparisons with the spectrum of a mercury lamp revealed no distinct difference.

Thallium.—The chloride of the metal was employed in this experiment, but no bands special to the compound were observed or photographed. The glow produced was bright green, and the spectrum consisted of numerous sharply defined lines. With the exception of two probable impurity-lines at 3239, 3220, the lines agree very closely with those of the arc spectrum, as regards their relative intensities, but there are indications that the second subordinate series is somewhat weaker than in the arc.

Nickel.—Nickel chloride was used, but the only bands observed were afterwards found to be identical with those given by cuprous chloride, and they may therefore be referred to an impurity of copper in the substance employed. Some of the lines of copper were also shown in the photographs. In addition, between 20 and 30 lines due to nickel itself were photographed, and these are identical with the strongest arc lines of the metal, so far as they can be identified with the small dispersion employed. The lines were most distinct in the ultra-violet region, 3620 to 2900, where there were no copper bands to mask them.

The Halogens.

Iodine.—The vapour given off by iodine at ordinary temperatures readily generates a characteristic bright blue glow when it comes in contact with active nitrogen. The spectrum shows a broad faint band in the green, and a number of ill-defined bands in the blue and ultra-violet, of which one at about 3430 is by far the most prominent (Plate 6, fig. 1). In addition, there is an apparently continuous background, which is feeble on the less refrangible side of a band at 4770, but is quite strong from that wave-length to the most refrangible part of the spectrum shown on the photographs. The bands as a whole do not appear to have been previously recorded, but the strongest band has been noted by Könen,[*] who describes it as extending from 3430 to 3340. We have found, however, that the vacuum tube shows all the bands of the glow spectrum in the region compared (3200 to 5900),

[*] 'Wied. Ann.,' 1898, vol. 65, p. 269.

but the vacuum tube differs from the glow in showing greater luminosity in the less refrangible parts of the spectrum. Also, while the most intense band in the vacuum-tube is at 4310, that in the glow is at 3430. Details relating to the bands of the glow spectrum are given in the appended table.

Wave-lengths of Iodine Bands.

Approx. wave-length.	Intensity.	Approx. wave-length.	Intensity.
4770	5	2890	3
4620	3	2835	2
4310	5	2775	2
3890	2	2720	1
3535	1	2480	2
3495	1	2430	1
3430	10	2380	1
3270	2	2075	5

The last on the list, at 2075, is a strong sharp line, quite unlike the others in appearance, but there seems to be no reason to assign it to any impurity, as it has not been found in mercury or any other substance likely to be present.

The band at 4770 was photographed with the Littrow spectrograph, but there were no signs of resolution into fine lines in a spectrum of purity 3000 in that region.

It should be noted that the flutings shown in fig. 1, which only occupy the upper half of the spectrum, are due to nitrogen.

Bromine.—The luminosity in this case was very feeble, and the photograph of the spectrum shows only one band which can be attributed to bromine. This is a broad symmetrical band, having ill-defined edges about 2930 and 2890. A band in the orange, dominating the colour of the glow, was observed visually.

[*Note added December 5.*—This band is not identical with the yellow-green band recorded in the vacuum tube spectrum by Eder and Valenta. With moderate dispersion it was found to consist of eight narrow bands extending from about 5875 to 6070, at nearly equal distances of 28 tenth-metres.]

Lines of aluminium were well seen in this spectrum, the metal having been carried forward into the glowing gas, probably in the form of a volatile bromide.

Chlorine.—The spectrum of chlorine excited by active nitrogen was similar to that of bromine, but the single broad band shown on the photograph occurs in a more refrangible part of the spectrum, namely, 2600 to 2540. No lines of chlorine were recorded on the photograph.

Compounds of Metals.

Cuprous Chloride.—The blue-green glow developed by cuprous chloride gives a spectrum which is generally similar to that of the same substance when volatilised in the Bunsen flame. The afterglow, however, produces a greater number of lines of copper, and the band spectrum of the chloride is more completely developed. The chloride bands are also better visible in the glow than in the flame, in consequence of the absence of overlying continuous spectrum. A series of bands which is either absent from the flame, or is very weak, is a conspicuous feature in the glow spectrum. These bands are more refrangible than those which occur in the flame, their approximate wave-lengths being 4150, 4080, 4010, 3945, 3885, 3835, 3785, 3740. The intervals between the bands suggest that they form a connected series which is related to those in which the flame bands have been arranged by Kien.[*]

Chlorides of Tin.—Stannous and stannic chlorides produce a brilliant blue glow. The most striking feature shown on a photograph of the spectrum of stannic chloride is an intense band in the blue, extending from about 4000 to 5000; with small dispersion, the band shows no signs of any maxima, and fades off gradually in both directions (Plate 6, fig. 2). In addition there are seven lines of tin between 3262 and 2706, which are identical with the strongest lines of the arc spectrum in this region. There are other faint lines at the approximate positions 3855, 3780, 3748, 3480, and 3474, which have not yet been identified.

A photograph of the blue band, taken with the Littrow spectrograph, shows that it is not perfectly continuous. Superposed on the continuous background, there are several symmetrical but ill-defined bands, 4 or 5 tenth-metres broad, which show no further signs of resolution in a spectrum of a purity of about 4000 in the region where the bands occur. Accurate measures of these bands cannot be obtained, and it will suffice to state that there are 15 bands between 4768 and 4430, at nearly equal distances of 24 tenth-metres. Some of the bands are double. The bands are very similar in appearance to those which occur in fluorescence spectra, as, for example, that of uranium phosphate. An experiment was accordingly made in order to ascertain if a fluorescence could be obtained by the action of ultra-violet light on stannic chloride.

A small quantity of stannic chloride was placed in a quartz tube, 2 cm. in diameter, which was exhausted and sealed, the liquid chloride being frozen with liquid air during this operation. The quartz tube was then

[*] 'Zeit. für Wiss. Photog.,' 1908, vol. 6, p. 337.

examined in a concentrated beam from an electric lantern with quartz condensers, with and without a deep violet glass. But no fluorescence could be observed, either at the ordinary temperature or when the tube was warmed.

Experiments on the vacuum-tube discharge through the vapour of stannic chloride showed that the discharge was generally similar in colour to the glow produced in active nitrogen, but was not so perfect a blue. The vacuum-tube spectrum, however, showed the same strong blue band as the glow, but there was also a fairly bright continuous, or nearly continuous, spectrum extending from the blue band to the red. Lines of tin were also more prominent in the vacuum-tube than in the glow.

Mercuric Iodide.—This substance yields a violet glow, and the spectrum shows bands which appear to be characteristic of the compound, together with a feeble band which coincides with the principal band of iodine about 3430. Mercury was only represented by the line 2536·7, which was no stronger than in other spectra obtained in the same manner when mercury was only accidentally present.

The strongest band begins at about 4455. It is very intense from that point to 4390, after which it fades off rather rapidly to the neighbourhood of 3700. With the small resolving power employed, the band is a nearly continuous one, but there are indications of numerous ill-defined maxima. The spectrum, as a whole, is similar to that described by Jones,[*] and afterwards by Lohmeyer,[†] as occurring in mercuric iodide rendered luminous in a vacuum tube. For the brightest band the wave-length of the beginning is given by Jones as 4396, but from the description there can be no doubt that it is the same band as that found in the glow. Lohmeyer's wave-lengths, giving the brightest parts of the band as lying between 4456 and 4393, confirm this. The remaining (faint) bands agree with those tabulated by Jones.

Sulphur and its Compounds.

Sulphur.—When sufficiently heated in the glowing nitrogen, sulphur gives a blue glow. The spectrum consists of a succession of bands, degraded to the red, and very evenly distributed. Between 4700 and 2800 there are about 30 principal bands, some of which are complex groups or doublets. There was little or no continuous spectrum. The spectrum has nothing in common with that of sulphur in a vacuum tube, but it is closely related to that given by the flame of carbon disulphide burning in air. In the

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[*] 'Ann. d. Physik.,' 1897, vol. 42, p. 50.

[†] 'Zeit. für Wiss. Photog.,' vol. 4, p. 376.

flame, however, the bands are superposed on a moderately strong continuous spectrum, and those which are more refrangible than 3400 are only very feebly displayed.*   When the flame was supported by oxygen, it was found that the bands were barely visible, while another group in the region 3000 to 3200 (seen also in the flame of burning sulphur) was introduced.

Sulphuretted Hydrogen.—The spectrum obtained when sulphuretted hydrogen was introduced into active nitrogen was identical with that given by sulphur in the nitrogen.

Carbon Disulphide.—The spectrum given by carbon disulphide in nitrogen showed the bands already described as occurring with sulphur, but the bands were only well developed on the less refrangible side of 3700. The cyanogen band 3883 and the carbon line 2478 were shown feebly.

In the ultra-violet there was an additional series of well-marked bands, degraded to the red, having their heads about 2550, 2592, 2620, 2665, 2700, 2745, 2785, 2830, 2920.   These bands were also present, in an ill-developed form, and superposed on continuous spectrum, in the carbon disulphide flame.   They appeared also in the spectrum of impure sulphurous anhydride in a vacuum tube, while the less refrangible group previously described was absent.

Further investigations will be undertaken to determine whether the different groups of bands represent different compounds of sulphur, or sulphur in different molecular states.

Compounds of Carbon.

The introduction of many of the compounds of carbon into the nitrogen afterglow results in the development of the spectrum of cyanogen, and direct chemical evidence of the formation of cyanogen has been obtained.†   The cyanogen spectrum was strongly developed in cyanogen, ethyl iodide, chloroform, carbon tetrachloride, and acetylene, and it was also seen, with less intensity, in methane, pentane, ethylene, alcohol, ether, and benzol.   An investigation of the spectra thus obtained, however, has revealed some interesting peculiarities.

The cyanogen spectrum, as given by the flame of the burning gas, has long been recognised as consisting of two principal sets of bands.   One of them occupies the red, yellow, and green parts of the spectrum, and the flutings composing the bands are degraded to the red.   The other consists of groups of flutings in the violet and ultra-violet, degraded to the violet, which

* The chief bands of the CS_2 flame spectrum are about 3370, 3420, 3500, 3557, 3590, 3645, 3680, 3740, 3835, 3940, 4050, 4080, 4160, 4200, 4275, 4310, 4440, 4480.

† R. J. Strutt, *loc. cit.*, p. 228.

are especially well known in consequence of their great brilliance in the spectrum of the carbon arc. For convenience of reference, these two sets of bands may be distinguished as the red and violet groups respectively. In addition, there are four groups of fainter flutings in the ultra-violet, degraded to the red, which have been regarded as the probable " tails " of the violet bands.*

The different compounds of carbon do not all behave in the same way when in contact with active nitrogen. In most cases, the " flame " produced was of a lilac tint, very similar to that of the cyanogen flame, but in the case of carbon tetrachloride, or chloroform, the flame was orange in colour and more luminous, and the red spectrum of cyanogen was more strongly developed in relation to the violet.

The " Red " Bands.—In carbon tetrachloride (Plate 6, fig. 3) and chloroform the red spectrum is very brilliant, and is particularly free from contamination with other spectra. The photographs give only feeble indications of the stronger of the second positive bands of nitrogen, and they show no traces of carbonic oxide, or of the Swan bands of carbon. Moreover, the system of bands can be traced clearly into the blue-green and blue, where there are several easily visible bands which are not seen, or only seen with difficulty, in the ordinary flame or vacuum-tube spectrum. This method of producing the spectrum accordingly offers special advantages for the study of the regularity of the bands, and it has been utilised by Messrs. Fowler and Shaw in a separate investigation of the red cyanogen spectrum as obtained from different sources.† Previous accounts of this spectrum have been very incomplete, and only roughly approximate wave-lengths of the bands have been available.

In the small scale photograph reproduced in fig. 3, and in visual observations, the bands appear to follow each other at nearly equal intervals and to show no marked discontinuity as regards their intensities. Other photographs taken with shorter exposures, however, show that the principal bands occur in groups of three, of which the middle one is the brightest in each case. It has been found that all the bands can be arranged in seven regular series, similar to those which constitute the first positive band spectrum of nitrogen.

The Violet Bands.—The familiar cyanogen bands in the violet and ultra-violet are greatly modified in all the carbon compounds which produce a visible luminosity when they are brought in contact with active nitrogen.

* King, 'Astrophys. Journ.,' 1902, vol. 14, p. 323 ; Jungbluth, 'Astrophys. Journ.,' 1904, vol. 20, p. 237.

† 'Roy. Soc. Proc.,' this vol., p. 118.

Considerable resolving power is necessary to show the character of the changes clearly, and the Littrow spectrograph was utilised in obtaining the comparative spectra which are reproduced on an enlarged scale in Plate 6, figs. 4 and 5. It will be seen that the details of the violet groups are very different in the glow as compared with the carbon arc.

Taking the 4216 band of the glow spectrum as a typical case, there is a modified development of the structure lines proceeding from the first and third heads (counting from red to violet, or right to left), and a partial suppression of the second and fourth heads. The structure lines emanating from the first head are identical with lines in the corresponding part of the arc band, but there is a conspicuous interruption of the sequence at a short distance from the head, after which the lines became stronger and overrun the second head, which itself appears to be rather weak. A similar effect is observed in the case of the third head, the structure lines of which overrun the fourth, but the third head is not nearly so strong as the first.

These effects are apparently identical with the variations in the negative band of nitrogen 3914, and in the cyanogen band 3883, which have been observed by Deslandres* as the pressure was reduced from one atmosphere to a few millimetres. We have confirmed this observation in the case of the first heads of the cyanogen bands 4216 and 3883, and the differences between the glow and arc bands, to which reference has so far been made, are therefore probably due, either directly or indirectly, to the fact that the cyanogen bands in the glow were produced at a relatively low pressure (5 to 10 mm.).

A still more striking difference between the glow and arc bands occurs in the most refrangible part of each of the violet groups. There is a special increase of intensity in this region, which may possibly be due to a local intensification of some of the series of structure lines, or to the introduction of entirely new bands. Until still greater resolving power can be employed, it will be difficult to determine the exact nature of the difference, but the development of new bands offers the simplest explanation. In favour of this view is the observation that the structure lines of the glow bands do not all occur in the bands of the arc, and also the fact that in some of the photographs (*e.g.* in cyanogen, Plate 6, fig. 6*a*) the supposed new bands are far stronger than the first heads of the groups. Assuming that new bands are developed, their less refrangible edges would be about 4495 (in the 4606 group), 4153 (in the 4216 group), and 3850 (in the 3883 group). Each band must then be supposed to consist of a group of close lines extending over about 9 tenth-metres, this group being followed by a gap of

* 'Comptes Rendus,' 1904, vol. 139, p. 1179.

about 3 tenth-metres, and this again by another group of lines extending over about 10 tenth-metres. The "new" bands are especially intense in ethyl iodide, cyanogen, and acetylene; they are also well marked in ethylene and chloroform, but are not nearly so pronounced in carbon tetrachloride.

Stimulation of cyanogen by the nitrogen afterglow is not the only means of producing these new bands, as they also appear on the photographs of the spectrum produced by the phosphorescent combustion of cyanogen in ozone.*

We have not yet succeeded in obtaining the new bands clearly in vacuum-tube discharges through cyanogen, but there were feeble indications of their presence when wide discharge tubes were employed.

Special care has been taken to show that the spectrum given by cyanogen itself in the nitrogen afterglow has the same peculiarities as that produced from other carbon compounds. When the cyanogen from mercuric cyanide is merely passed through a phosphorus pentoxide drying tube, the removal of water vapour is not complete, and the hydrocarbon band 4315 usually appeared in the spectrum obtained. It seemed possible, therefore, that the modifications of the violet bands in this case might result from the presence of hydrocarbons formed by interaction of water vapour with cyanogen. An experiment was accordingly made in which the cyanogen introduced into the afterglow had been kept in contact with the drying agent for five days. In this case (fig. 6*a*) the hydrocarbon band did not appear, but the violet cyanogen bands presented the same appearances as before. Hence, the stimulation of ready-made cyanogen by active nitrogen produces the same modifications of the violet bands as are observed when the gas is produced by the interaction of nitrogen with other carbon compounds which give luminous effects. The modified bands therefore do not represent cyanogen in course of formation, as might, perhaps, have been supposed. As previously suggested,† it would seem that cyanogen is immediately produced by admixture of the carbon compounds with active nitrogen, and that the observed spectrum is due to the subsequent stimulation of the gas by the peculiar conditions existing in the afterglow.‡

The Cyanogen "Tail" Bands.—The ultra-violet groups of flutings, fading

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* R. J. Strutt, 'Phys. Soc. Proc.' The "unknown" bands mentioned in this paper as occurring at 431 and 415 appear to be respectively the hydrocarbon band 4315 and the new band of cyanogen 4153. The cyanogen band 4606 is also represented by a band about 450, which would correspond with another of the new cyanogen bands.

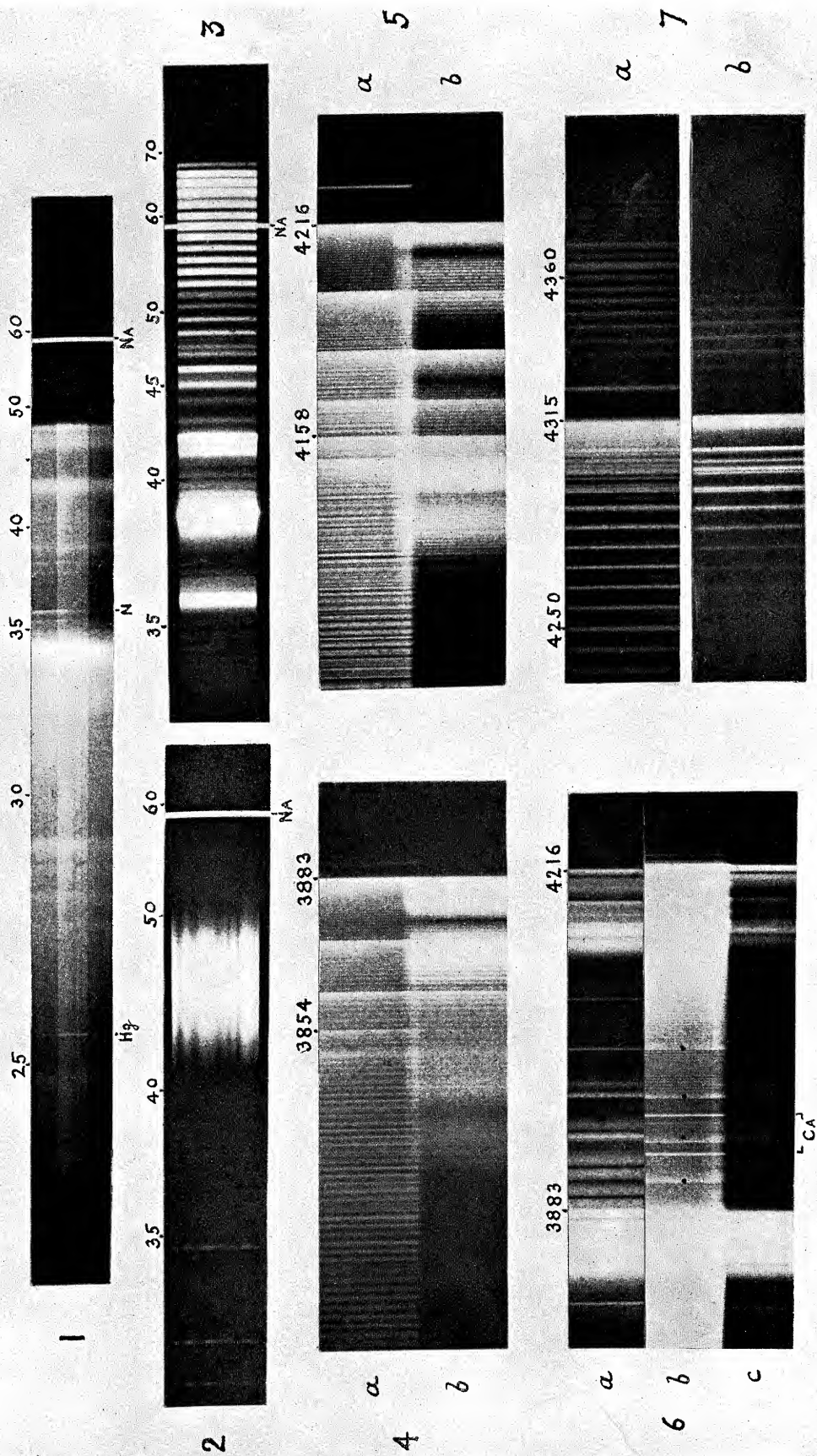† R. J. Strutt, 'Roy. Soc. Proc.,' vol. 85, p. 228.

‡ It should be mentioned that the photographs of the spectrum generated by the specially dried cyanogen in the afterglow of nitrogen show two of the bands (4679 and 4365) of the "high pressure" spectrum observed in carbon monoxide by Fowler

towards the red, which have been regarded as tails of the violet groups, are also very considerably modified in the glow cyanogen as compared with their appearances in the carbon arc (Plate 6, fig. 6, where the bands in the arc are indicated by black dots). So far as can be determined from the photographs available, including some taken with the Littrow spectrograph, the bands are changed in the glow in the same manner as the first heads of the 4216 and 3883 groups; that is, there is an intensification of the structure lines near the head of each band, a conspicuous break in the sequence of the lines at a short distance from the head, and a greater development of the lines immediately following the break. It is probable that a complete investigation of the structure of these bands, in relation to the modified violet bands, would throw additional light on the supposed connection of the two groups, but it would be a laborious piece of work, and cannot at present be undertaken. In addition to the bands noted by King at 3910, 3945, 3985, there is evidently one near 3883, and another about 4030.

The Hydrocarbon Band 4315.—The hydrocarbon band 4315 appeared in the glow spectrum in the case of carbon compounds which contain hydrogen, and in cyanogen which had not been completely freed from water vapour. Like the cyanogen bands, this also shows very considerable modifications as compared with the bands obtained from flames. This will be seen from Plate 6, fig. 7, in which the band given by the oxy-coal-gas flame is compared with that given by acetylene in nitrogen. No new lines appear in the glow band, but there are great differences in the relative intensities of the structure lines in the two spectra. Particularly striking is the concentration of luminosity about the head of the band at 4315. This is followed by a dark space about 5 tenth-metres broad, on the more refrangible side, after which there is a special intensification of the first half-dozen structure lines. On the less refrangible side, the flame line 4324 almost disappears in the glow, and the more refrangible members of the group lying between 4335 and 4390 are especially developed. The character of the change corresponds generally with that of the violet cyanogen bands, and of the negative band of nitrogen 3914, under reduced pressure, and the variations are possibly to be accounted for in the same manner.

('Monthly Notices R.A.S.,' vol. 70, p. 490). These bands had not then been observed in any other compound of carbon and were provisionally attributed to carbon monoxide ; their presence in cyanogen may have been due to an impurity, or the real origin of the bands may be carbon. The bands in question are generally similar in structure to the new cyanogen bands 4495, etc., and it is remarkable that they occupy positions with respect to the bands of the Swan spectrum corresponding to those which the new cyanogen bands occupy with respect to the violet bands 460, 421, and 388.

SPECTRA DEVELOPED IN NITROGEN AFTERGLOW

Summary and Conclusions.

(1) The spectra generated by the nitrogen afterglow do not differ fundamentally from those which can be produced by other means of excitation. In many cases, however, band spectra are better displayed in the glow, and the more refrangible parts of the spectrum are more completely developed. The method therefore adds to our resources for the production of spectra.

(2) The spectra of metallic substances approximate to those obtained in the electric arc, or are intermediate between arc and flame spectra. In the case of sodium, when sufficiently heated, the maximum intensity in the principal series is at λ 3303, the D lines being nearly extinguished.

(3) The spectra given by iodine, chloride of tin, and mercuric iodide are very similar to those obtained from vacuum tubes. There is, however, a greater development of the more refrangible parts of the spectrum in the case of the glow.

(4) The band spectrum of cuprous chloride is more completely developed in the glow than in the Bunsen flame. It shows an additional series of bands in the ultra-violet which is probably related to the series which constitute the flame spectrum.
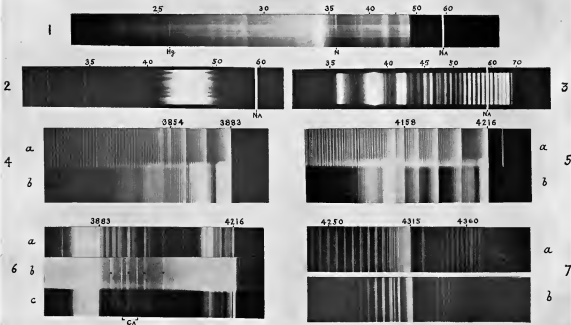
(5) The spectra exhibited by sulphur, sulphuretted hydrogen, and carbon disulphide consist of bands which are quite distinct from those given by sulphur in a vacuum tube, but resemble the bands of the carbon disulphide flame in air.

(6) The cyanogen spectrum which is developed in the glow by cyanogen and certain other compounds of carbon differs in several respects from that observed in the cyanogen flame or carbon arc. Some of the differences appear to be due to the production of the spectrum at a relatively low pressure in the glow. A new set of bands, occupying positions near the more refrangible edges of the violet groups, occurs in the glow spectrum, and has also been observed during the phosphorescent combustion of cyanogen in ozone.

DESCRIPTION OF PLATE.

(1) Spectrum of iodine in afterglow.

(2) Spectrum of stannic chloride in afterglow.

(3) Spectrum of cyanogen produced by carbon tetrachloride in afterglow.

(4), (5) The cyanogen bands 4216 and 3883; (*a*) as given by carbon arc in air; (*b*) as given by acetylene in the afterglow.

(6) A group of "tail" bands of cyanogen; (*a*) and (*c*) as given by cyanogen and carbon tetrachloride respectively in the afterglow; (*b*) as given by the carbon arc in air. The marked heads are 3910, 3945, 3985, 4030. The greater development of the new bands 4153, 3850, by cyanogen, as compared with carbon tetrachloride, is also shown.

(7) The hydrocarbon band 4315; (*a*) as given by the oxy-coal-gas flame; (*b*) as given by acetylene in the afterglow.

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